All Fired Up For Safety

Safety Lessons from the Natural Gas Industry

Brian Foy

DuPont Protection Technologies

The DuPont Company is a 211 years old global business built on a foundation of science and safety.

- 2012 Revenue $34.8 billion.
- Consistently rated one of the safest companies in America.
- Operates in 90 companies with 61,000 employees around the world.
- More than 150 research and development and customer service labs in 35 countries around the world.

- ***Unique technology, processes and products from the application of leading edge science.***

- **NOMEX®, KEVLAR®, TYVEK®, TEFLON®** are just a few of the innovations well known to industry and consumers.
- DuPont touches your life everyday. In your home, your car and on your job there are dozens of DuPont products.

- ***Fire science and fr ppe is a core competency.***

- We developed the materials and testing which define high performance protection today.
- We continue to invest in the future, globally running over 1000 thermal mannequin burn tests per year.

Agenda

- Why FR PPE? Burn Injury Fundamentals.
- Natural Gas Industry and Employee Statistics
- Standards
- FR PPE usage
- FR Technology
- Thermo-Man (ASTM F1930) Thermal Mannequin Test Method

Why Not Wear Regular Work Clothes?

Flammable Fabrics:

Cotton

Wool

Silk

Flammable Fabrics that Melt:

Polyester

Nylon

Polypropylene

If the clothing fabric ignites and burns, it will INCREASE the extent of a worker's injury.

Burn Injury Fundamentals

1st Degree:

Skin Becomes Red, But Doesn't Blister

2nd Degree Or Partial Thickness Burn:

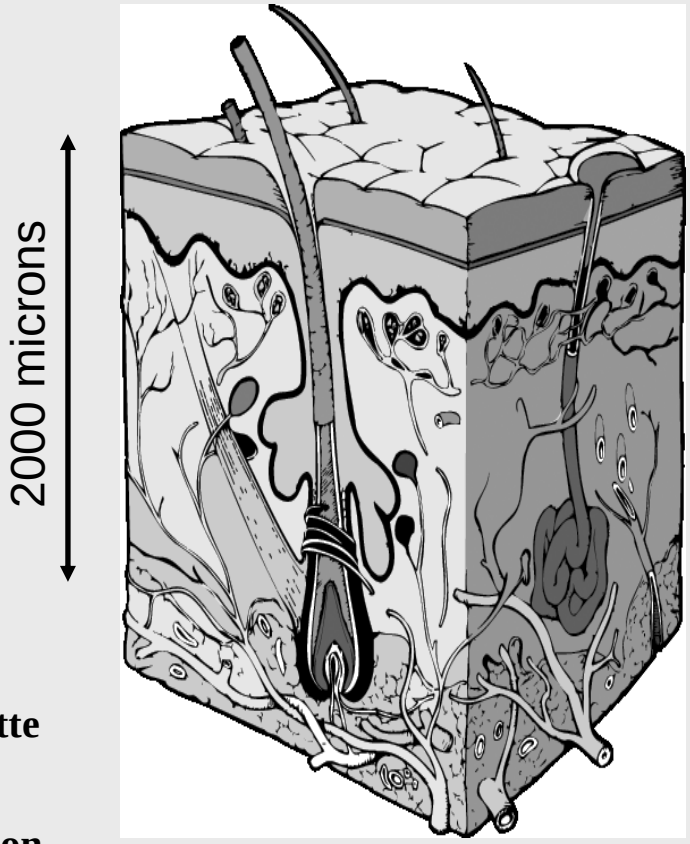
Skin Blisters, Epidermis Must Regenerate

~100 Microns In Depth

3rd Degree Or Full Thickness Burn:

Full Thickness Of Skin Destroyed, Skin Can Not Regenerate, Scar Tissue Forms

1,000 to 2,000 Microns In Depth



Fire Exposure Energy

- **Units Are cal/cm^2 (calories per square centimeter)**
- **1 cal/cm^2 Is Equivalent to the Energy Produced by a Cigarette Lighter in One Second on Tip of a Finger**

How Much Exposure Energy is Required for a Second Degree Burn on Bare Skin?

- **1.2 cal/cm^2**

Most Fire Exposures Will Cause Burn Injury To Exposed Skin and Ignite Flammable Clothing

Clothed areas can be more severely burned than exposed skin!

Why Does FR PPE Matter?
A Single Burn Injury is Very Expensive

How Much?

*For <u>all</u> burn injuries of 40% - 60% TBSA**

Average Hospital Stay is 60 Days (survivor)

22 days (fatality)

Average Cost of that Hospital Stay - $555,000 (survivor)

$280,000 (fatality)

Fire/Flame Hospitalizations are More Costly

Fire contact can result in immediate – and more - 3rd degree burns.

<u>BUT</u>

Burn Injuries Only Begin with Hospitalization

Per OSHA

The Total Cost of a Burn Injury is Much-Much More Expensive.

PER INCIDENT!

* - American Burn Association National Burn Repository® 2011.

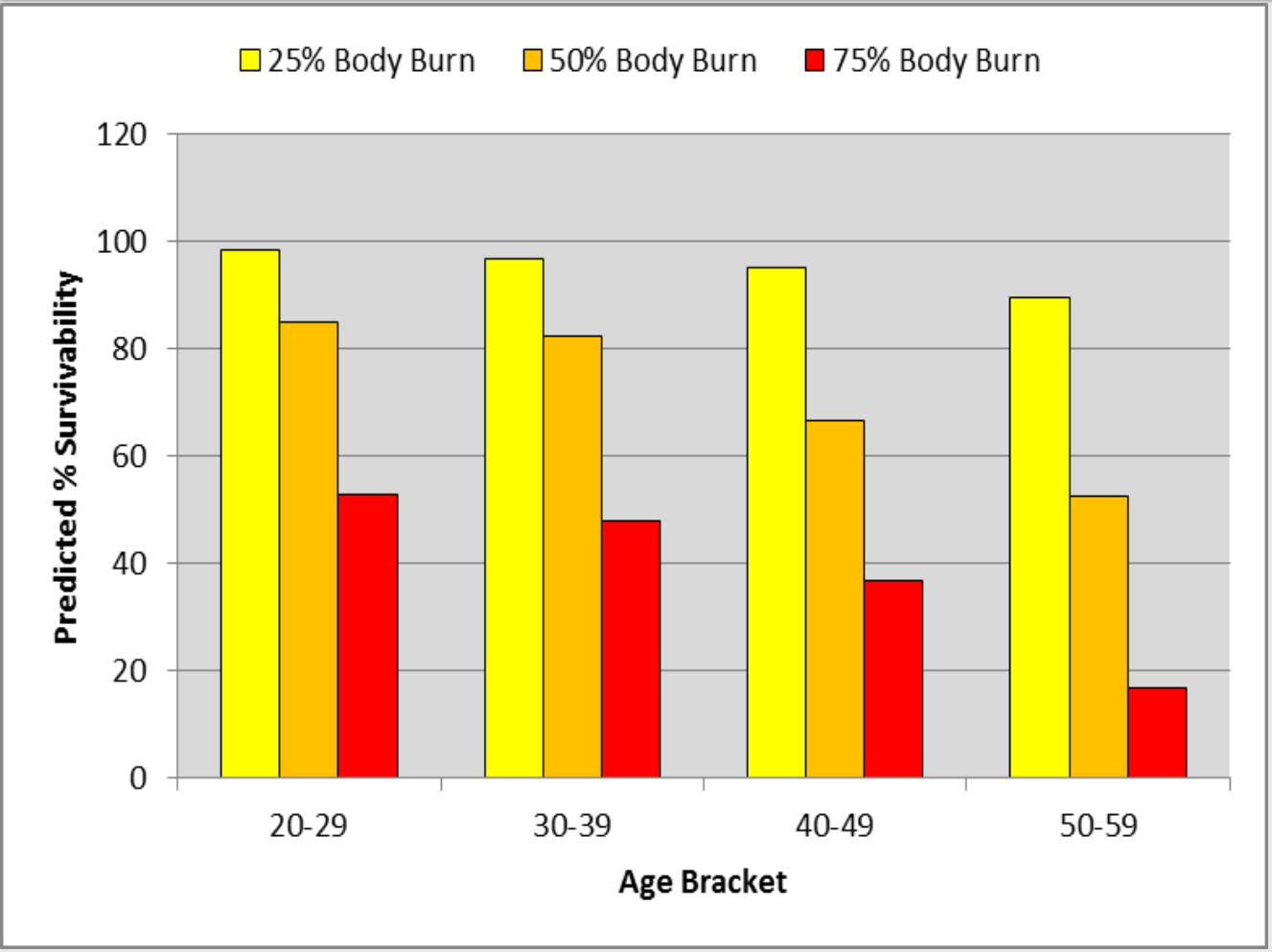
Bottom Line

Every study that has been done has shown that a well designed and executed fr ppe program is less expensive than even just one serious burn injury.

Chances of surviving a flash fire decrease…

- as burn injuries increase
- as you get older

Chances of Survival



Chances of surviving a flash fire decrease…

- **as burn injuries increase**
- **as you get older**

American Burn Assoc Chart Data, Figure 1, Probit of Survival Curves, Saffle, J.R., Davis, B, Williams, P, and ABA Registry Participant Group, "Recent Outcomes in the Treatment of Burn Injury in the Unites States: A Report from the American Burn Association Patient Registry", J Burn Care Rehabil, 1995, 16, 219-32

Natural Gas Industry and Employee Statistics

There are about 1600 natural gas utilities across the U.S., from large multi-state entities down to a municipal utility supplying one small population area.

In 2011 (most recent data), there were 122,000 employees in the natural gas industry, 111,000 in investor owned natural gas companies and an additional 11,000 in municipally owned utility companies.

Industry consolidation and the contracting of services that started in the mid 1990's reduced the total number of employees.

From 1971 through about 1990 the industry workforce averaged some 215,000. By the late 1990's that number was down to 150,000.

The workforce has remained fairly constant over the 5 years prior to 2011 at approximately 121,000.

The data and statistics presented are representative of the natural gas gathering, transmission and distribution companies, downstream of the wellhead.

Natural Gas Industry and Employee Statistics

With 122,000 employees spread among some 1600 natural gas utilities the average number of employees per utility is roughly 76. This represents a challenge to the spread of best practices in fr ppe safety.

The growth of contracted operations is a separate issue, and as equally challenging.

There is no national consensus standard for the protection of natural gas industry workers, despite unique needs.

• When referenced, most natural gas companies cite NFPA 2112 as the guide

BUT

• Hazard Assessments completed by natural gas companies have established the desire for utility specific fr ppe ***above the garment minimum performance requirements of NFPA 2112***.

WHY?

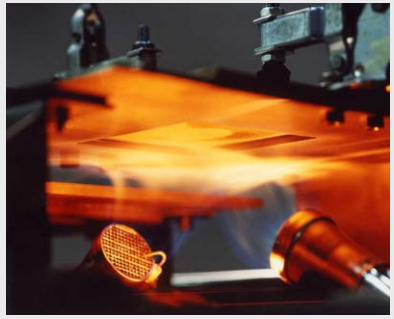
•Two primary reasons:

- • desire for a reduction in allowable predicted body burn vs standards.
- • recognition of increased escape time.

Let’s look at those NFPA 2112 standards:

NFPA 2112 "Standard on Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire"

- **Relevant Consensus Standard**
- **Vertical Flammability (fabric)**
- **Thermal Protective Performance (TPP) (fabric)**
- **Thermal Shrinkage Resistance (fabric)**
- **Heat Resistance (fabric)**
- **Sewing Thread Composition & Performance (sewing thread)**
- **Instrumented Thermal Manikin (purpose made garment)**
  - **(3 sec. @ 2 cal/cm2.sec., pass if body burn percentage is 50% or less)**



Allows garments to be marketed as "FR"

…….but NFPA 2112 compliant garments do not give you NFPA 2113 compliance.

NFPA 2113, 2012 Edition
Standard on Selection, Care, Use, and Maintenance of Flame-Resistant Garments for Protection of Industrial Personnel Against Flash Fire
Chapter 4 – Selection

Item 4.1, #1–"Do a hazard assessment"

(Figure out what you need to protect against)

Item 4.1, #2–"Evaluate available fr garment designs and characteristics."

(Figure out what PPE will work)

Item 4.1, #3–"Develop purchasing specifications"

(Go buy it)

Spec also covers:

- **How to use (eg: sleeves down and collars closed)**
- **Care (keep the garments clean, launder per mfgs recomm.)**
- **Maintenance (inspect and repair routinely and correctly)**

Spending Some Time in the Weeds

There is only one NFPA 2112 test that uses something that looks like the FR PPE you would buy. That's the Thermal Mannequin Burn Test.

Notes….

- **The test uses a specially made coverall – not commercial garments – of only one size.**
- **The burn test is conducted with only 100% cotton t-shirt and briefs under the test garment.**
  - **If this is how the employees dress then the data is relevant.**
- **The test uses a standard "fire" using propane as the fuel with a heat flux of 2 cal/cm2-sec for 3 seconds.**
  - **A hotter fire or a longer exposure will change the burn injury, and it can be a substantial change.**

This is why a Hazard Assessment is so important!

How are those standards applied in the natural gas industry?

When natural gas companies test their PPE on the thermal mannequin test (ASTM 1930), versus the NFPA 2112 minimum garment spec of 2 cal/cm2-sec for 3 seconds max 50% body burn requirement, gas companies test to*:

25% of companies test to 8 seconds or more
44% at 4 seconds or more
13% at less than 4 seconds
19% "other"

Why?

Companies looked at the specifications and their jobs and did their own hazard assessments. They found that NFPA 2112 wasn't good enough, that they needed to do their own testing. Lots of different solutions arrived at.

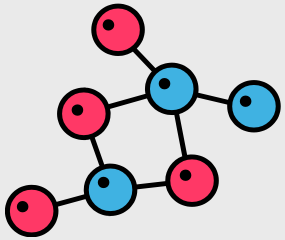
- But no company that DuPont has worked with has accepted a 50% maximum body burn percentage as acceptable.

* AGA Survey Data, N=18

OK, Let’s talk FR PPE Technology

There are two basic types of FR fabrics, and they respond differently when exposed to heat and flame

Recent years has added a mix of the two

Fabric Type		Response
Chemically Treated Ex: Indura® Ultrasoft®, Banwear®, Dale Antiflame®		FR chemicals are “activated” by intense heat, producing char and gases that inhibit combustion.
Inherent Ex: NOMEX®, KEVLAR®, PBI®,		DNA of the fiber does not support combustion.
Blends Ex: NOMEX® MHP, Tecasafe		Combinations of fibers

What Makes One FR Garment Better Than Another?

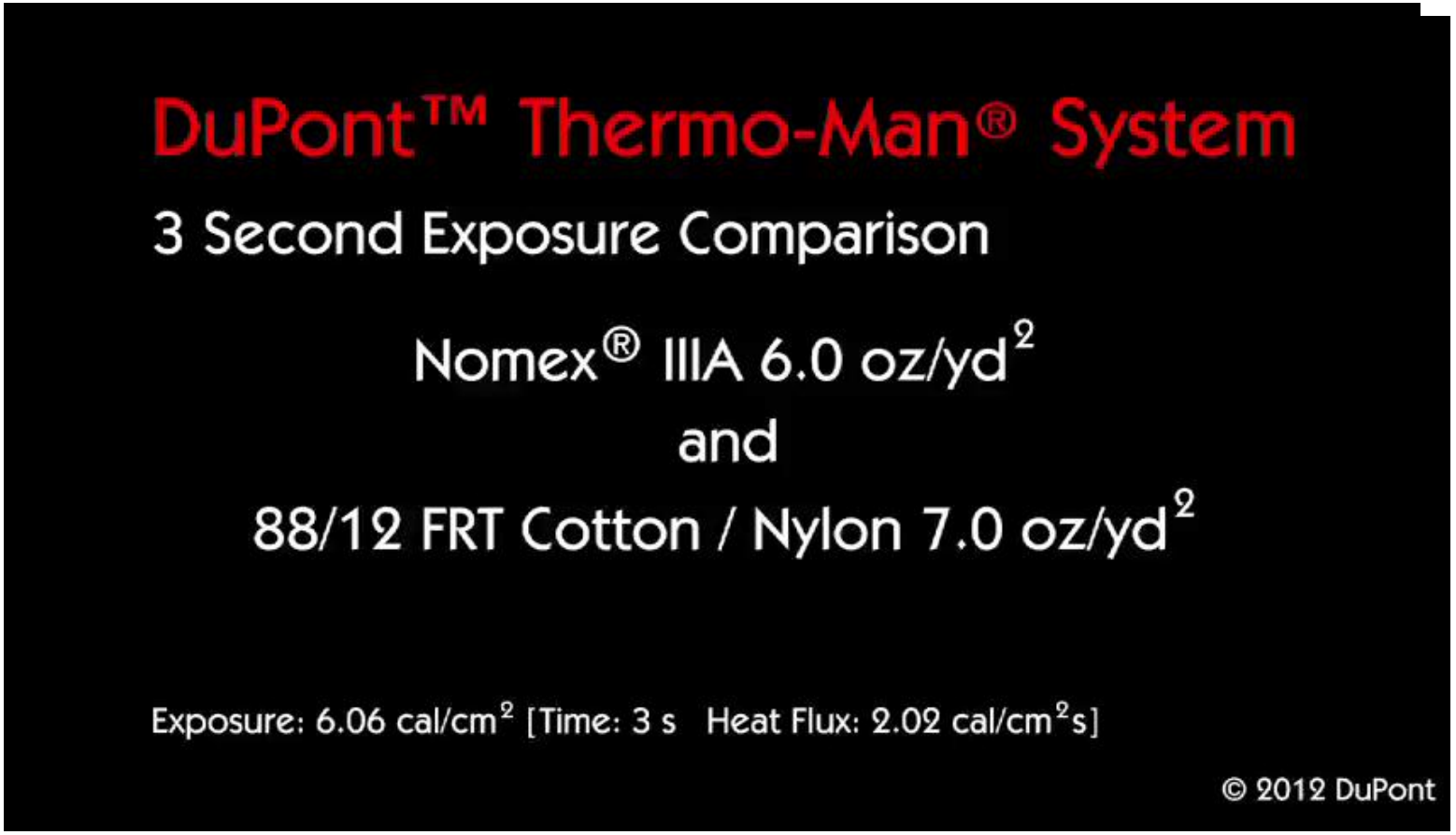
- Not all materials react the same way to fire. Some don't burn, some burn and char, some burn and melt. There will also be differences in the intensity of the combustion process.

- A good general statement is that the heavier the garment, the longer it will take to ignite so heavier is more protective. Downside is that when it ignites there's a lot of fuel to burn.
- ..and that heavy garment creates its own problems.

- When comparing one garment to another – OF THE SAME MATERIAL
- Heavier weight is better (more barrier but less comfort)
- More coverage is better (less open skin)
- Looser fit is better (more air space)
- Multiple layers add protection (extra trapped air insulation)

DURATION AND INTENSITY CAN IMPACT BODY BURN INJURY %

NFPA 2112 Performance Requirement



NOMEX® IIIA - 6 oz/sy **3 seconds @ 2.02 cal/cm²s** **Total Exposure: 6.06 cal/cm²** **16.4% Body Burn Injury**	**88/12 FR Treated Cotton / Nylon – 7 oz/sy** **3 seconds @ 2.02 cal/cm²s** **Total Exposure: 6.06 cal/cm²** **11.5% Body Burn Injury**

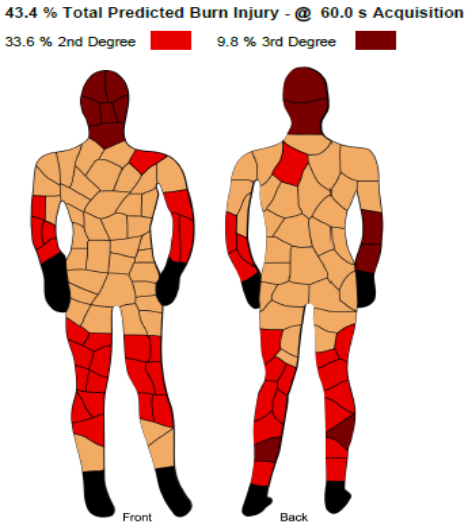
DURATION AND BODY BURN INJURY %

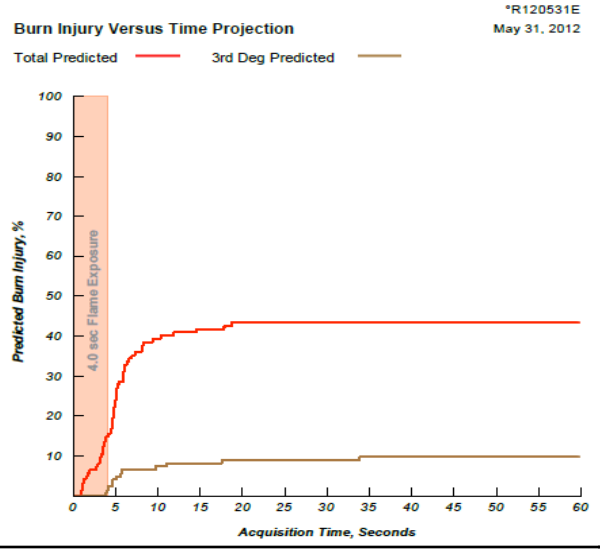
You can impact total exposure by changing duration

NOMEX® IIIA - 6 oz/sy **4 seconds @ 2.06 cal/cm²s** **Total Exposure: 8.24 cal/cm²** **43.4% Body Burn Injury**	**88/12 FR Treated Cotton / Nylon – 7 oz/sy** **4 seconds @ 2.06 cal/cm²s** **Total Exposure: 8.24 cal/cm²** **77.9% Body Burn Injury**

NOMEX® IIIA, 6 oz/sy

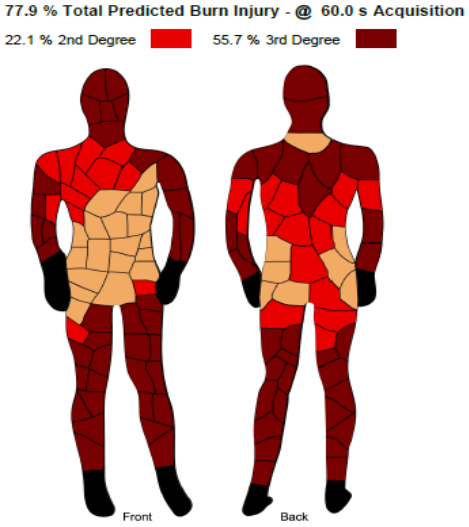
- 4 seconds @ 2.06 cal/cm^{2}s
- Total Exposure: 8.24 cal/cm^2
- **Burn Injury: 43.4%**

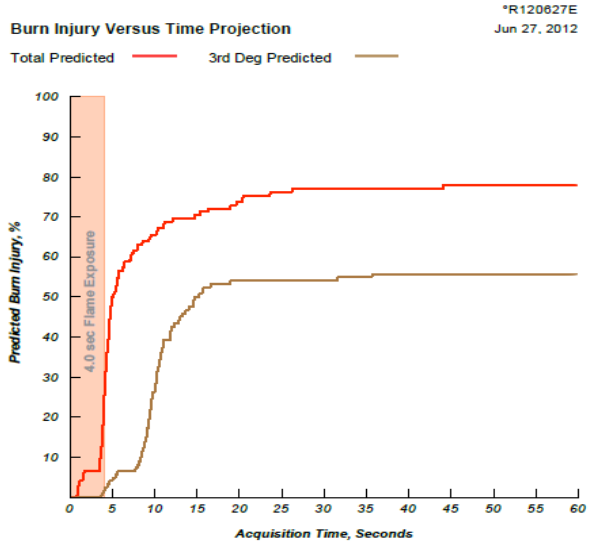




88/12 FR Treated Cotton / Nylon , 7 oz/sy

- 4 seconds @ 2.06 cal/cm^{2}s
- Total Exposure: 8.24 cal/cm^2
- **Burn Injury: 77.9%**



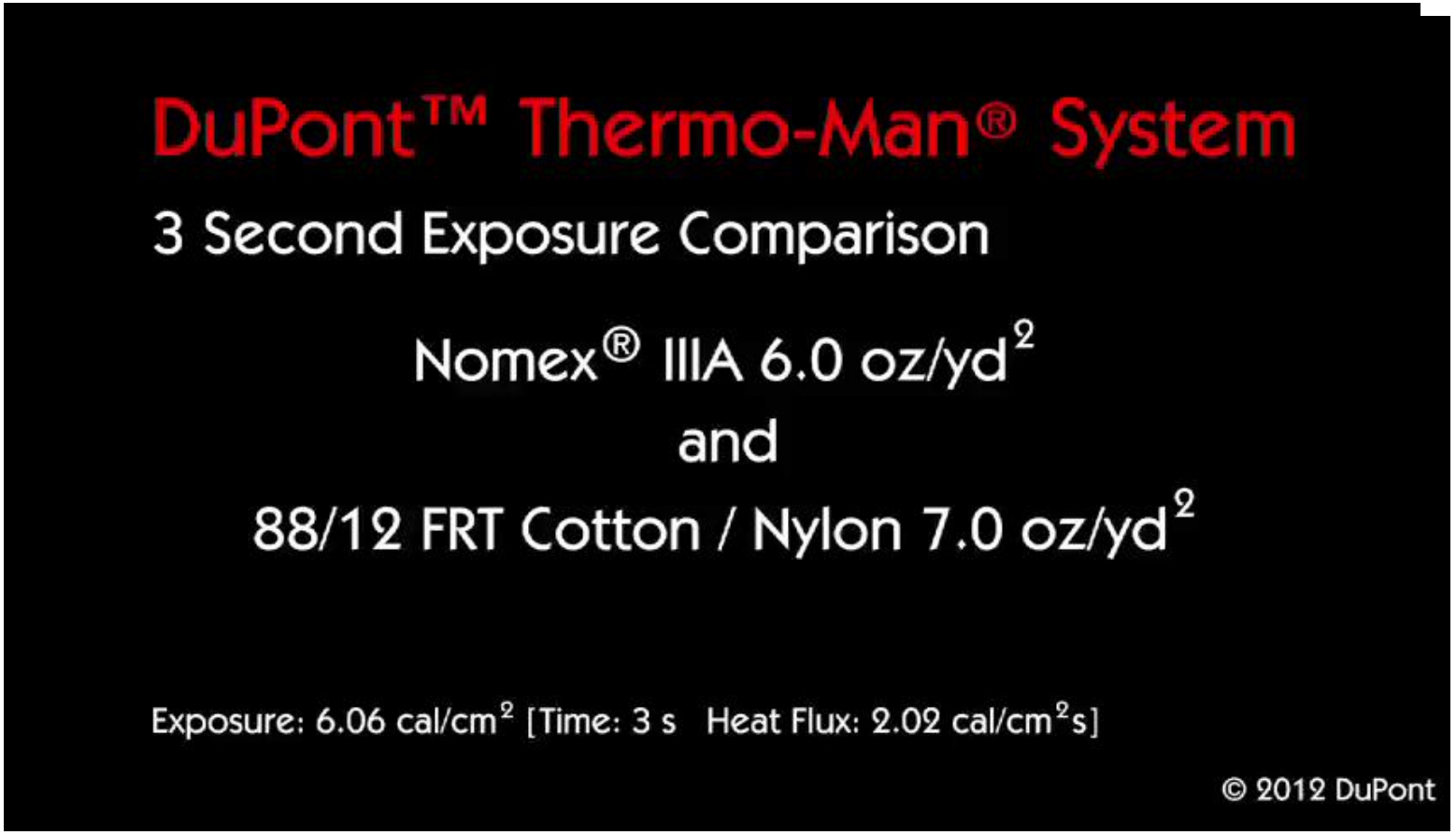


BODY BURN INJURY % AT INCREASED DURATION

DUPONT
Nomex.

DURATION AND INTENSITY CAN IMPACT BODY BURN INJURY %

NFPA 2112 Performance Requirement



NOMEX® IIIA - 6 oz/sy **3 seconds @ 2.02 cal/cm²s** **Total Exposure: 6.06 cal/cm²** **16.4% Body Burn Injury**	**88/12 FR Treated Cotton / Nylon – 7 oz/sy** **3 seconds @ 2.02 cal/cm²s** **Total Exposure: 6.06 cal/cm²** **11.5% Body Burn Injury**

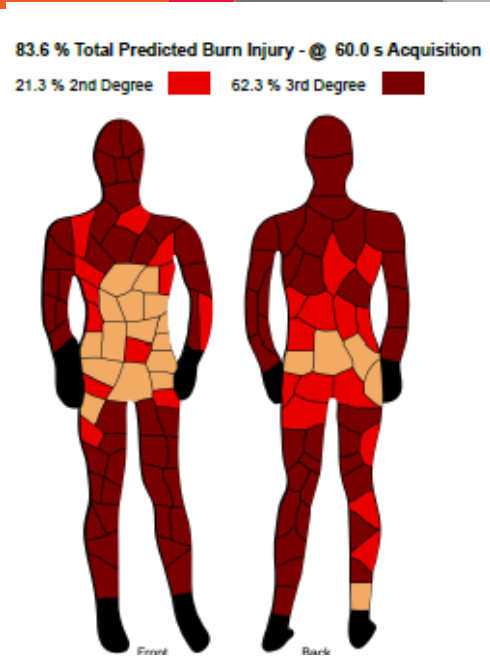
INTENSITY AND BODY BURN INJURY %

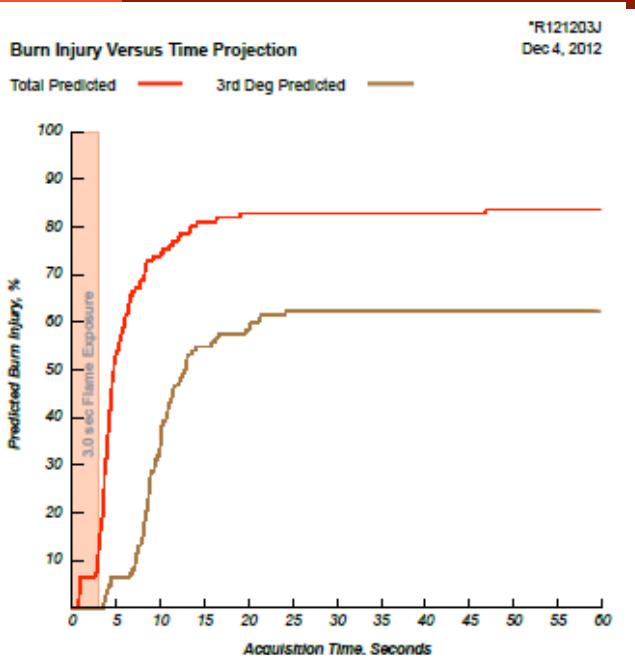
You can generate total exposure by changing intensity

NOMEX® IIIA - 6 oz/sy **3 seconds @ 2.36 cal/cm²s** **Total Exposure: 7.08 cal/cm²** **43.4% Body Burn Injury**	**88/12 FR Treated Cotton / Nylon – 7 oz/sy** **3 seconds @ 2.36 cal/cm²s** **Total Exposure: 7.08 cal/cm²** **83.6% Body Burn Injury**

88/12 FR Treated Cotton / Nylon , 7 oz/sy

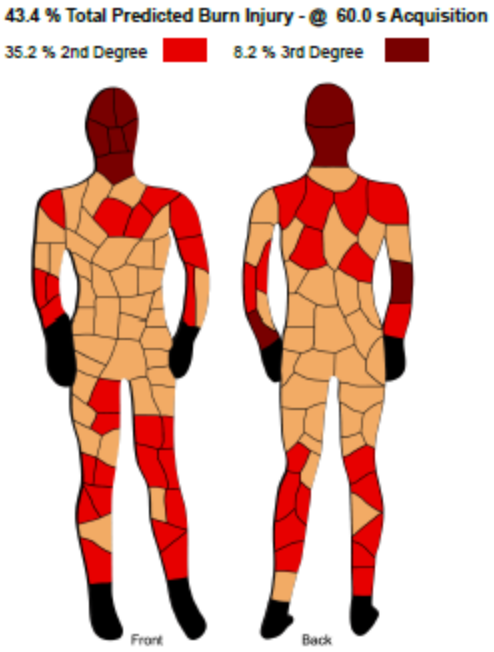
- 3 seconds @ 2.36 cal/cm^2
- Total Exposure: 7.08 cal/cm^2
- **Burn Injury: 83.6%**

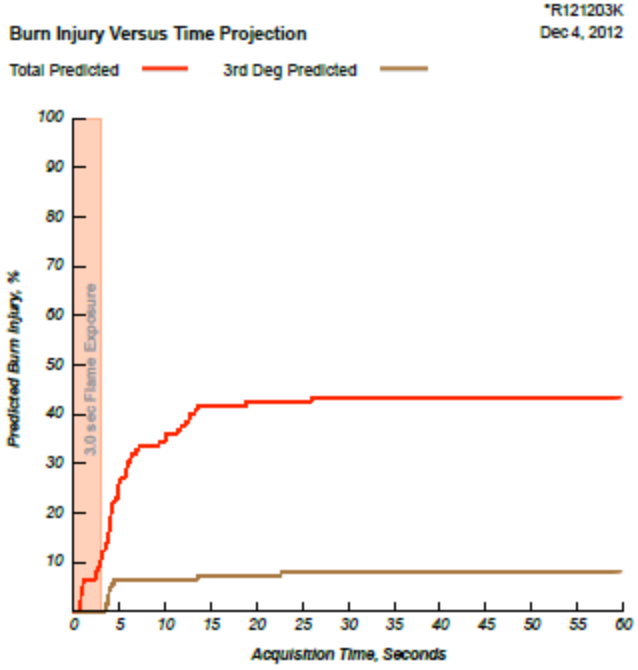




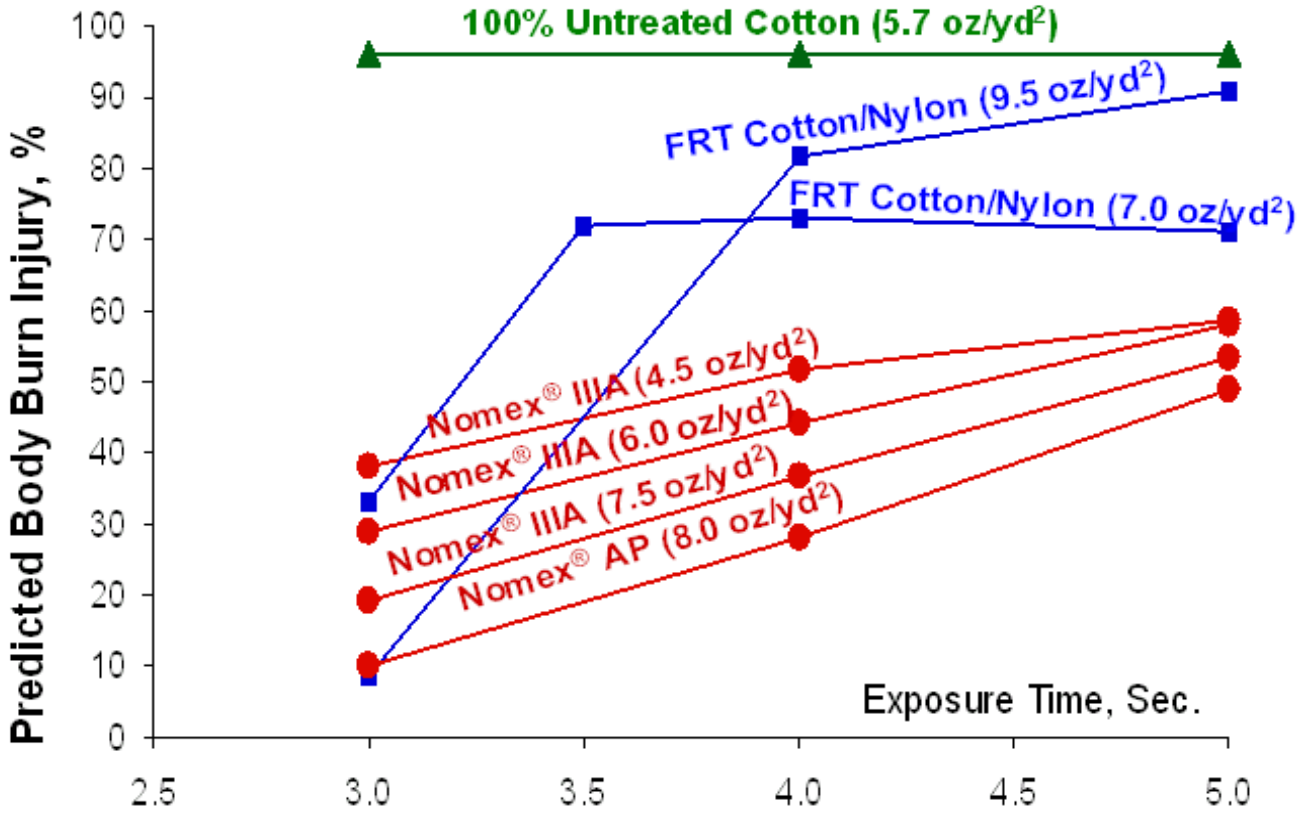
NOMEX® IIIA, 6 oz/sy

- 3 seconds @ 2.36 cal/cm^2
- Total Exposure: 7.08 cal/cm^2
- **Burn Injury: 43.4%**





Thermal Performance of NOMEX®



- FRT Cotton or FRT Cotton/Nylon: Burn injuries can increase dramatically at exposures greater than 3.0 seconds
- Nomex®: Superior protection across a range of exposures

Conditions

Standard pattern coveralls tested using ASTM F 1930 test method.

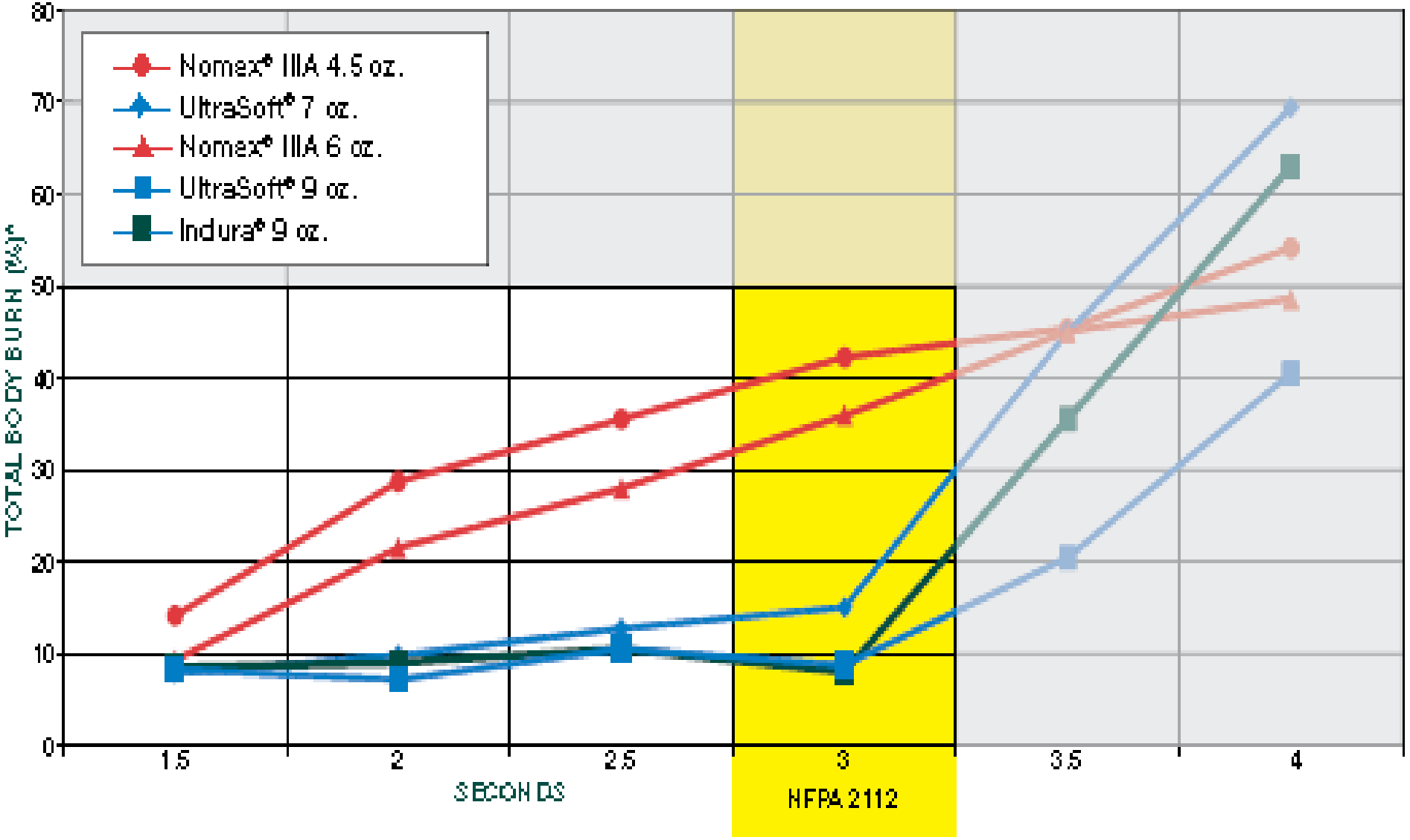
All coveralls were exposed to a 2 cal/cm²s heat flux; each data point represents the average of three values.

All garments were laundered and dried one time before testing; 100% cotton undergarments were used.

NOMEX® garment response is linear with fire exposure.

DUPONT
Nomex.

ALL WEIGHT FABRICS



*Note: 88% is the maximum possible since the hands and feet are excluded. All figures include 7% for the head.

Excerpted from the current Westex Overview Brochure

Importance of the Outermost Layer Being Flame Resistant

What is this Thermal Mannequin Test?

- **First, some history…..**

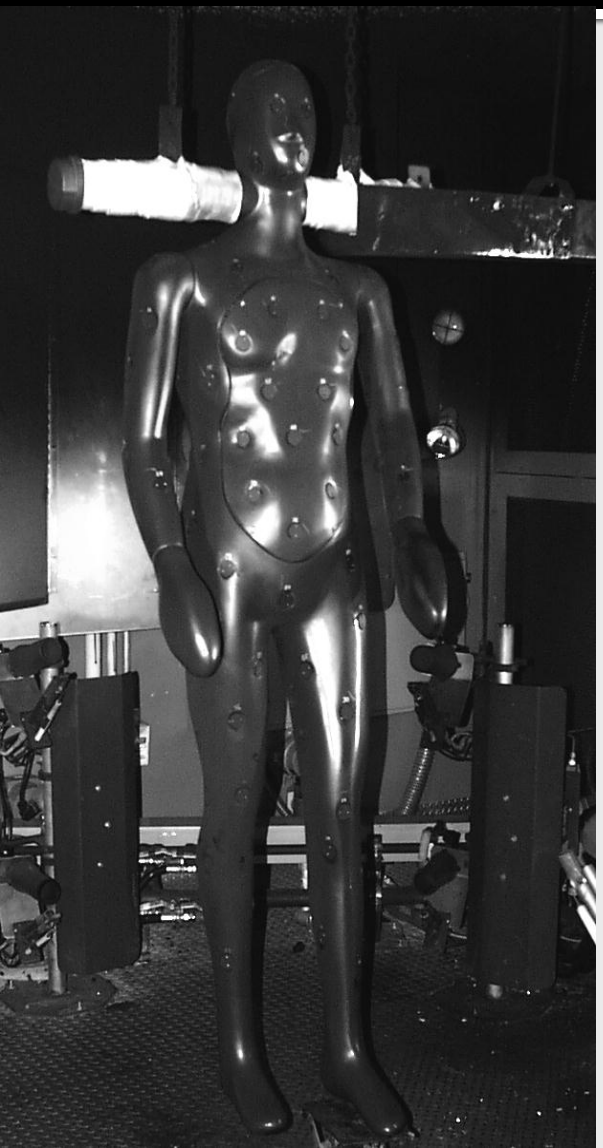
Original military test used a JP4 aviation fuel pool fire


Early
Thermo-Man

"*Thermo-Man" Thermal Mannequin – Measures Garment Response to Fire Event and Estimation of Burn Injury*

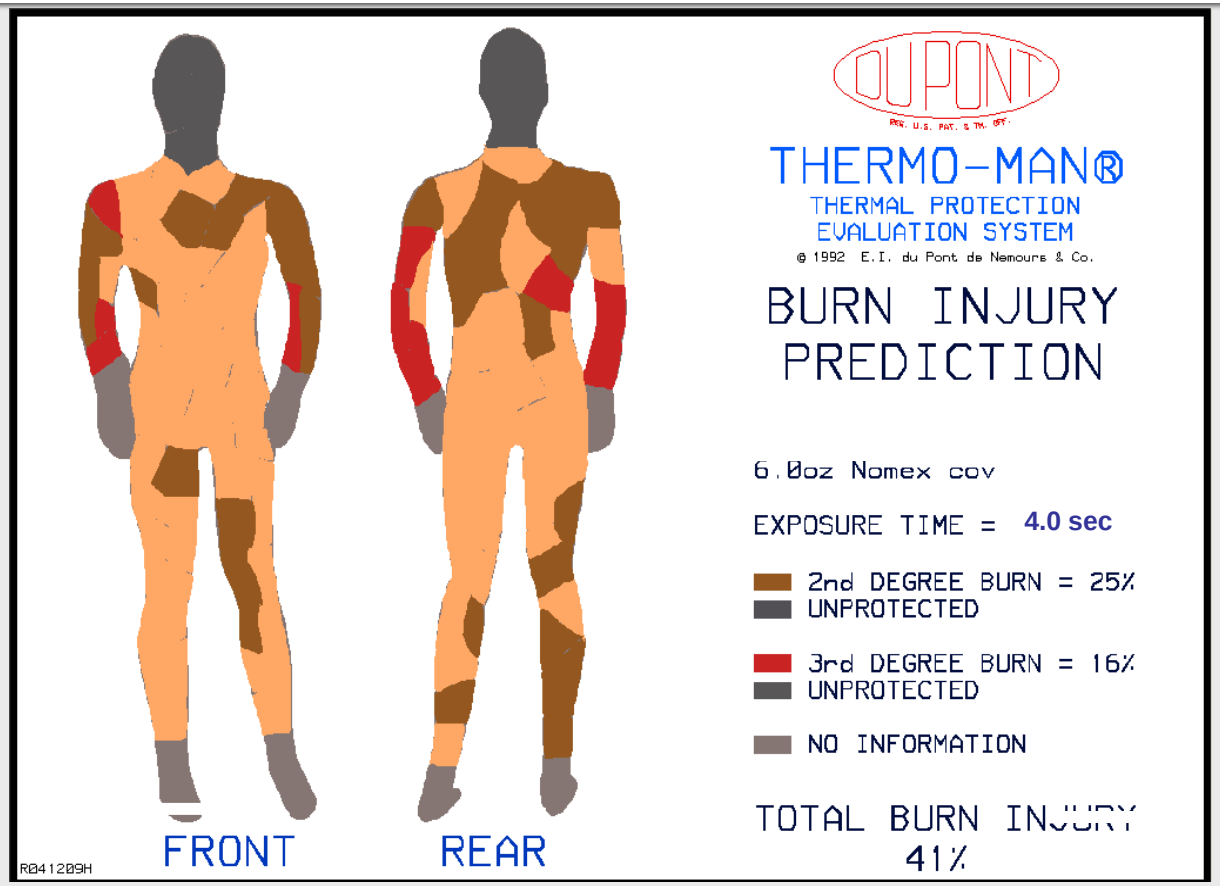
- **"Jet" Fire Exposure Chamber**
- **Fire of Specific Intensity / Duration**
- **Developed by U.S. Military & DuPont**
- **Burn Injury Predicted for Garment or System**
- **Three Facilities in North America**
  - ✓ **DuPont**
  - ✓ **North Carolina State University**
  - ✓ **University of Alberta, Canada**
- **ASTM Standard (ASTM F-1930)**
- **NFPA Uses for Certification of Garments**

"Thermo-Man" Thermal Mannequin – Measures Garment Response to Fire Event and Estimation of Burn Injury

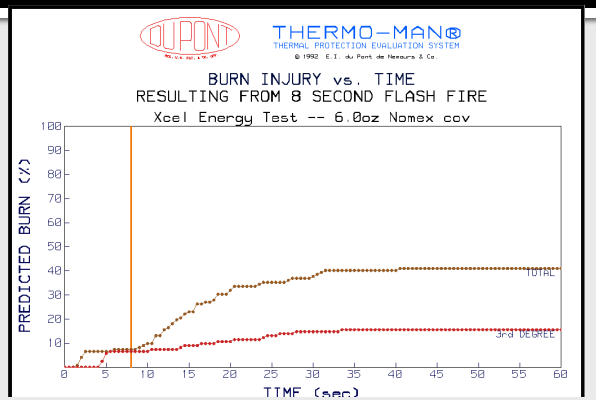


- **Full Size Instrumented Mannequin**
  - **High Temperature Polyester/Fiberglass Composite**
  - **Size 42-44R Coverall**
  - **XL Shirt, 38W 32L Pants**
- **122 Thermal Sensors Distributed at Surface**
  - **Specialized Epoxy/Glass "Slug Calorimeters"**
  - **Approximate Skin Thermal Response**
  - **No Sensors in Hands & Feet ~ 12% of Body Surface**
- **Computer Data Acquisition & Analysis System**
  - **Acquires Mannequin Calorimeter Values**
  - **Calculates Skin Burn Injury Using Data & Model**
  - **American Burn Assoc Survivability Model**

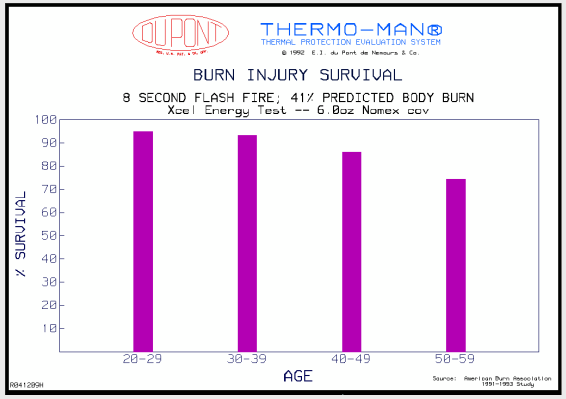
Thermo-Man® Information



Degree, Location and Level of Potential Burn Injuries of Specific Garment System.



Burn Injury Timeline



Survival Rates

Instrumented Thermal Mannequin Test ASTM F-1930

Limitations

- **No Body Movement**
- **Can not duplicate fit of commercial garments to any specific person**
- **Expensive**
- **Serves only to provide standardized relative performance of FR fabrics**
- **Cannot Simulate All Actual Accident Conditions**

Summary

- **The lack of industry specific standards can hamper the safety professional in identifying best practices.**
- **A hazard assessment is crucial in identifying threats to employee safety.**
- **Increased escape times are an industry reality**
- **The ASTM 1930 Thermal Mannequin Test is an excellent tool to identify fr ppe garment performance.**

If your not sure what it will do, test it!

An offer

DuPont extends the opportunity for your company to assess the performance of your fr ppe gear at our Thermo-Man laboratory in Richmond, Virginia.

- You bring your gear.
- Tested to how you expect it to be worn.
- Data and videos will be available for each burn.

Besides leaving with an understanding of the performance of your fr gear you will have the data for:

- Your due diligence of a hazard assessment.
- Your internal safety training.

DuPont makes this *no cost* offer to share knowledge.

Knowledge is the key to improving employee safety

Acknowledgements

The data contained in this presentation is:

- Industry statistics and safety survey data collected by the American Gas Association.
- Government data available from the U.S. Energy Information Administration
- Web based company level research
- One-on one end user interviews

THANK YOU

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Disclaimer

The information in this presentation was prepared as a possible aid to use when considering protective apparel of DuPont Nomex® brand fiber. Anyone intending to use recommendations contained in this presentation should first be satisfied that the information is suitable for their application and meets all appropriate safety and health standards. Refer to other DuPont publications for safe handling and use instructions for all types of NOMEX® brand fibers before using products. Both manufacturing and end-use technologies may undergo further refinements; therefore, DuPont reserves the right to modify the information contained herein as additional knowledge and experience are gained.

Electric arc data is based on testing at the Kinectrics Laboratory in Toronto, Canada. Fabric samples were exposed to laboratory simulations of an electrical arc pursuant to ASTM Standard F-1959-99. This test method is used to measure the arc thermal performance value of materials intended for use as flame resistant clothing for workers exposed to electric arcs that would generate heat flux rates from 2 to 600 cal/(cm2*sec). The results of these tests are a range and only predictions of material performance under controlled laboratory conditions.

Because the dynamics of electrical arcs vary greatly, these results do not duplicate or represent garment or fabric performance under actual electrical arc conditions. The user is solely responsible for any testing of their own fabric, interpretations of this data, and for all conclusions and implications made concerning the relationship between the test data and real life burn injury protection. This data is not intended for use by the user or others in advertising, promotion, publication or any other commercial use.

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